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I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003905247 for a patent by REDFERN OPTICAL COMPONENTS PTY LTD as filed on 25 September 2003.

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J. Billingsley

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PROVISIONAL SPECIFICATION

Applicant(s):

REDFERN OPTICAL COMPONENTS PTY LTD

Invention Title:

CODING OPTICAL WAVEGUIDES

The invention is described in the following statement:

Coding Optical Waveguides

Field of the Invention

The present invention broadly relates to methods for applying optical codes to optical waveguides and to optical waveguides that have encoded information.

Background of the Invention

The amount of optical fibre that is being installed is constantly increasing. Metropolitan areas already have dense networks of optical fibres. For example, in exchange stations often hundreds of fibres are branching and crossing. Installation of fibre networks and manual routing changes therefore are difficult tasks and mistakes can be made. It is essential to mark the optical fibres so that they can be identified, but suitable markings such as bar codes on the fibres are not ideal as they can only be identified locally. Optical fibres often have a length of many (hundred) kilometres and a large number of bar codes needs to be applied to the fibres in intervals to ensure that the optical fibre can be identified at any interrogation position.

There is a need for a better method of coding fibres that allows the identification of the fibres at different locations without the need to apply a large number of bar codes.

Summary of the Invention

The present invention provides in a first aspect a method of applying a code to an optical waveguide comprising

- encoding information and forming an optical code and
- applying the optical code to the optical waveguide in a manner such that in use the optical code will induce a change of at least one property of optical radiation that passes through the waveguide, the change of the or each property being characteristic for the encoded information.

The information may be of any type and the optical code may function as a read only memory (ROM). In one example, the information is useable to identify the optical waveguide. The optical code is detectable by optical radiation that passes through the waveguide and, dependent on the waveguide properties, the waveguide may therefore be identifiable at any interrogation position along the waveguide even if the optical code itself is remote from the position of interrogation.

The step of applying the optical code to the waveguide may comprise writing a refractive index variation into a core of the waveguide. For example, the refractive index variation may be selected so that the optical radiation that passes through the waveguide experiences amplitude and/or phase changes which can be used to retrieve the encoded information. The refractive index variation may be written so that an optical filter is formed in the waveguide.

In one embodiment of the invention the refractive index variation is written into the core so that a Bragg grating is formed in the core of the waveguide. The Bragg grating may be a multi-channel grating that has a specific amplitude and/or phase response as a function of wavelength.

The step of encoding the information may comprise usage of encoding schemes such as phase shift keying and preferably comprises phase amplitude keying (PAK).

The present invention provides in a second aspect an optical waveguide that has a code applied by the above-defined method.

The present invention provides in a third aspect an optical read-only memory (ROM) comprising a waveguide having a Bragg grating which is associated with encoded information and that in use imposes amplitude and/or phase changes on optical radiation that passes through the waveguide, the imposed changes being characteristic for the encoded information.

The Bragg grating may be a multi-channel Bragg grating and may have a number of possible phase and amplitude levels for each channel.

The present invention provides in a fourth aspect a method of obtaining information from at least one optical waveguide, the or each waveguide having an optical code that comprises encoded information, the method comprising
- directing optical radiation through the or each optical waveguide to the or each optical code so that the or each optical code will impose a change of at least one property of the optical radiation, the change of the or each property being characteristic for the encoded information,
- receiving the optical radiation having the or each changed property and thereafter
- processing the optical radiation to obtain the information.

The information may be of any type and the optical code may function as a read only memory (ROM). In one example, the information is useable to identify the or each optical waveguide.

A Laser pulse may be directed through the or each optical waveguide to the or each optical code which may be a Bragg grating. At least a portion of the optical radiation may be reflected by the or each Bragg grating and the step of processing the optical radiation may comprise analysing the reflected or transmitted optical radiation to identify a specific amplitude and/or phase response of the or each Bragg grating. The or each grating may be a multi-channel Bragg grating and the step of directing optical radiation to the optical code may comprise directing light from a tunable laser to the multi-channel Bragg grating. In this case, the method may further comprise scanning the wavelength of the laser through a wavelength range that corresponds to the channels of the or each multi-channel Bragg grating and successively receiving the optical radiation that has the or each changed property characteristic for the encoded information. Alternatively, a laser pulse such as a square pulse may be directed to the multi-channel grating and the phase and amplitude changes effect changes on the envelope of the pulse.

In one embodiment, the encoded information comprises directions for the installation of the or each optical waveguide. In this case the method may comprise the additional step of installing the waveguide according to the directions. For example, the or each optical waveguide may be an optical fibre and the step of installing the or each optical fibre may comprise splicing

the or each optical fibre according to the directions. The method may be conducted in an automated way in which the obtained information is processed and used to install a plurality of optical fibres in a predetermined manner.

The optical waveguides may also be a part of an optical network. In this case, each optical waveguide may comprise an optical code that has encoded information which can be used to identify the waveguide. For example, the optical radiation may be directed to a plurality of waveguides and the step of processing the optical radiation may comprise characterising the network. This may comprise identifying if a response from an optical code in a particular optical waveguide is not present which would indicate a defect. Further, each optical code may be at a known position within each waveguide and the quality of signal transmission through the network to the known position may be tested by directing the optical radiation to each optical code and characterising the received radiation.

The invention will be more fully understood from the following description of preferred embodiments of the invention. The description is provided with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 shows a schematic representation of an optical device having an optical code according to a preferred embodiment of the invention,

Figure 2 shows a plot of grating amplitude versus position for the device shown in Figure 1 and

Figure 3 shows a plot of grating phase versus position for the device shown in Figure 1.

Detailed Description of Preferred Embodiments

Referring to Figure 1, a device comprising an optical fibre 10 having an optical coding is now described. The optical fibre 10 has a core 12 and a cladding 14. Written into the core 12 is a refractive index variation that forms a multi-channel Bragg grating 16. Figures 2 and 3 show the amplitude and phase versus position plots for the grating 16 which correspond to encoded information. Light of suitable wavelength that is directed through the Bragg grating 16 will experience changes in amplitude and phase that are characteristic for the encoded information and the light can be processed to retrieve the encoded information.

In one embodiment, the Bragg grating 16 has 80 channels that correspond to different wavelengths. Using a multilevel coding scheme such as phase amplitude shift keying, each bit of a bit sequence may be converted into a specific phase/amplitude coordinate code in a phase/amplitude coordination system. A Bragg grating such as grating 16 having the specific phase and amplitude properties may then be written using conventional techniques.

For example, each channel of the multi-channel grating may have a number of possible different phase and amplitude levels. Further, each channel may have a number of wavelength divisions. In a specific example, each channel has 8 possible phase levels, 8 possible amplitude levels and 5 wavelengths divisions. Therefore, the number of possible combinations is 81 x 8 x 8 x 5 = 25920 and a grating of this type can store one of 25920 different encoded bit sequences. It will be appreciated that the number of channels, amplitude levels, phase levels, and

wavelength divisions may alternatively be significantly larger (or smaller) than those in the specific example. The Bragg grating 16 thus is a read-only memory that has a memory size which depends on these parameters. For example, the grating may be arranged to have a memory size of several Mb or more.

To read the read only memory, a laser may be used such as a multi-longitudinal mode Fabry Perot semiconductor laser. In this example, the laser has resonances that correspond to the channels of the grating 16. The laser may generate a square pulse which is directed through the fibre core 12 to the grating 16. The laser light will experience amplitude and phase changes and a portion of the pulse is reflected by the grating. Owing to the amplitude and phase changes, the envelope of the pulse will be changed. The reflected light is then detected and converted into an electrical signal. The converted signal is then processed by a microprocessor to retrieve the information that is encoded in the Bragg grating 16.

Alternatively, a tunable laser may be used to generate the optical radiation. The wavelength of the laser may be scanned across the channels of the multi-channel grating. A phase and amplitude sensitive detector detects the optical signal that is reflected from the multi-channel grating. In a multi-level decoding sequence the signal may be decoded and the information retrieved.

For example, the information that is encoded into the Bragg grating 16 may be useable to identify the optical fibre itself. As the Bragg grating 16 is detectable by optical radiation that passes through the waveguide, the fibre 10 may be uniquely identifiable at any interrogation

position along the fibre 12 even if the Bragg grating itself is remote from the position of interrogation.

In another example, the encoded information comprises directions for the installation of the optical fibre 10. For example, the encoded information may comprise direction for splicing fibres. In this example, the encoded information may enable "intelligent splicing" in which a plurality of fibres are spliced together in an automated way to form a predetermined configuration which can be automatically verified by reading the code.

The encoded information can also be of use for testing optical networks. Each optical waveguide (planar waveguide or fibre) in the network may comprise a Bragg grating that has encoded information which can be used to identify the respective waveguide. For example, the laser radiation may be directed to a plurality of the waveguides and the light that is reflected from the Bragg gratings can be processed to characterise the network. For example, it may be identified if a response from an optical code in a particular optical waveguide is not present which would indicate a defect. Further, optical codes may be at a predetermined position within the waveguides of the network. For example, the radiation that is reflected by the respective Bragg gratings may be tested for chromatic dispersion, polarisation-mode dispersion (PMD) and signal attenuation. Results may be used to derive information about the quality of signal transmission at the known position of the optical codes.

Although the invention has been described with reference to particular examples, it will be appreciated by those skilled in the art that the invention may be embodied in many other forms in any type of optical waveguide. For example, the optical code may not be

implemented in form of a Bragg grating. Further, it will be appreciated that the or each waveguide may take any suitable form including planar optical waveguides and optical fibres made from glass and/or polymeric materials.

The Claims defining the Invention are as Follows:

1. A method of applying a code to an optical waveguide comprising

- encoding information and forming an optical code and
- applying the optical code to the optical waveguide in a manner such that in use the optical code will induce a change of at least one property of optical radiation that passes through the waveguide, the change of the at least one property being characteristic for the encoded information.

2. The method as claimed in claim 1 wherein the step of applying the optical code to the waveguide comprises writing a refractive index variation into a core of the waveguide.

3. The method as claimed in claim 2 wherein the refractive index variation is selected so that the optical radiation that passes through the waveguide experiences amplitude and/or phase changes which can be used to retrieve the encoded information.

4. The method as claimed in claim 2 or 3 wherein the refractive index variation is written into the core so that a Bragg grating is formed in the core of the waveguide.

5. The method as claimed in any one of the preceding claims wherein the step of encoding the information comprises usage of an encoding scheme.

6. An optical waveguide that has a code applied by the method as defined in any one of the preceding claims.

7. An optical read-only memory (ROM) comprising a waveguide having a Bragg grating which is associated with encoded information and that in use imposes amplitude and/or phase changes on optical radiation that passes through the waveguide, the changes being characteristic for the encoded information.

8. The optical waveguide as claimed in claim 7 wherein the Bragg grating is a multi-channel Bragg grating.

9. A method of obtaining information from at least one optical waveguide, the or each optical waveguide having an optical code that comprises encoded information, the method comprising

- directing optical radiation through the or each optical waveguide to the or each optical code so that the or each optical code will impose a change of a property of the optical radiation, the change of the property being characteristic for the encoded information,
- receiving the optical radiation having the changed property and thereafter
- processing the optical radiation to obtain the information.

10. The method as claimed in claim 9 wherein the optical code functions as a read only memory (ROM).

11. The method as claimed in claim 9 or 10 wherein the optical radiation is a Laser pulse and the or each optical code is a Bragg grating.

12. The method as claimed in claim 11 wherein at least a portion of the optical radiation is reflected by the or each Bragg grating and the step of processing the optical radiation comprises analysing the reflected or transmitted optical radiation to identify the specific response of the or each Bragg grating.

13. The method as claimed in any one of claims 9 to 12 wherein the encoded information comprises directions for the installation of the or each optical waveguide.

14. The method as claimed in claim 13 comprising the additional step of installing the waveguide according to the directions.

15. The method as claimed in claim 14 wherein the or each optical waveguide is an optical fibre and the step of installing the or each optical fibre comprises splicing the or each optical fibre according to the directions.

16. The method as claimed in any one of claims 9 to 15 in which the or each optical waveguide is a network of optical waveguides and each optical waveguide comprises an optical code that has encoded information which can be used to identify the waveguide.

17. The method as claimed in claim 16 wherein the step of processing the optical radiation comprises characterising in the network.

18. The method as claimed in claim 17 wherein characterising the network comprises identifying if a response from an optical code in a particular optical waveguide is not present.

19. The method as claimed in claim 17 or 18 wherein each optical code is at a known position within each waveguide and the quality of signal transmission through the network to the known position is tested by directing the optical radiation to each optical code and characterising the received radiation.

DATED this 25th day of SEPTEMBER 2003
REDFERN OPTICAL COMPONENTS PTY LTD
By their Patent Attorneys
GRIFFITH HACK

Fig. 3

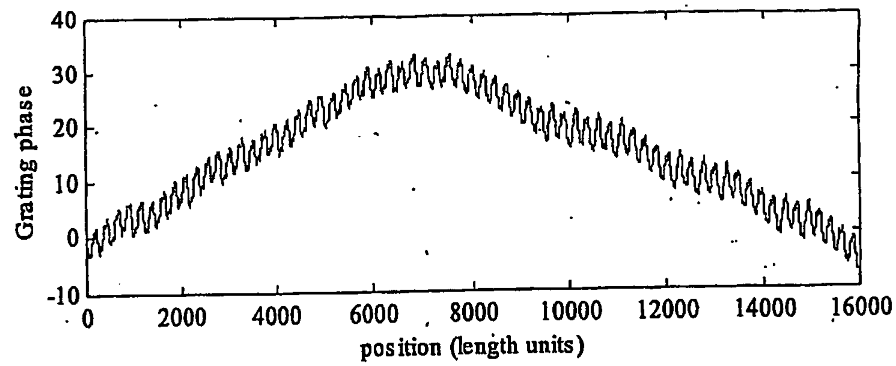
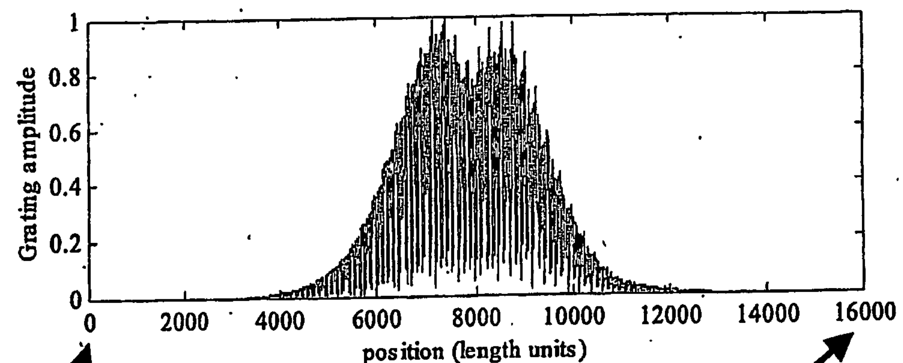


Fig. 2



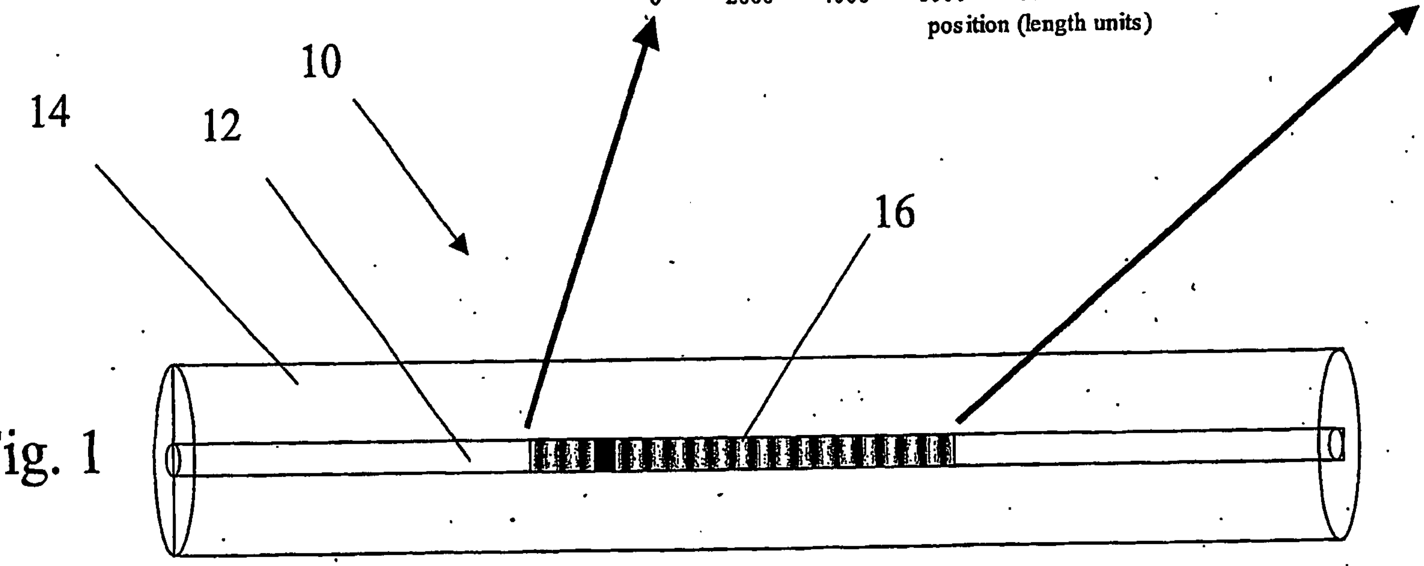


Fig. 1

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